

Radiation exposure from diagnostic nuclear medicine examinations in Golestan province

Hamid Javadi¹, Ali Mahmoud Pashazadeh², Mehdi Mogharrabi³, Isa Neshandar Asli⁴,
Faraj Tabei^{4,5}, Ali Asghar Parach⁶, Majid Assadi²

¹Golestan Research Center of Gastroenterology and Hepatology, Golestan University of Medical Sciences, Gorgan, Iran

²The Persian Gulf Nuclear Medicine Research Center, Bushehr University of Medical Sciences, Bushehr, Iran

³Department of Nuclear Medicine, 5th Azar Hospital, Golestan University of Medical Sciences, Gorgan, Iran

⁴Department of Nuclear Medicine, Taleghani Hospital, Shahid Beheshti University of Medical Science, Tehran, Iran

⁵Department of Medical Physics & Engineering, Shahid Beheshti University of Medical Sciences, Tehran, Iran

⁶Department of Medical Physics, Shahid Sadoughi University of Medical Sciences, Yazd, Iran

(Received 18 May 2013, Revised 9 July 2013, Accepted 14 July 2013)

ABSTRACT

Introduction: The aim of present study was to estimate effective dose from most common procedures performed in nuclear medicine departments of Golestan province.

Methods: Data of nuclear medicine procedures performed in 2 nuclear medicine departments in Golestan province were collected during 4 years. Effective dose, collective effective dose and effective dose per examination were calculated using standard dosimetry tables.

Results: Based on the data of this study, results of 10437 nuclear medicine procedures performed during 4 years have lead to 3.97 mSv as average effective dose per examination and 10.37 human-Sv as mean collective effective dose. It was also revealed that Tc-99m was the main source of effective dose (98.3%), bone scan was the most common procedure (25.9%) and cardiac scan (MIBI-rest) has the highest collective effective dose (33.5%) during 4 years.

Conclusion: Beside the cardiac scan which was the most common nuclear medicine procedure and the main contributor of effective dose in patients, due to geographical condition of the northeast of Iran, bone scan was the highest performed nuclear medicine examination in the Golestan province.

Key words: Effective dose; Nuclear medicine procedures; Collective effective dose

Iran J Nucl Med 2013;21(2):65-69

Published: October, 2013

<http://irjnm.tums.ac.ir>

Corresponding author: Ali Mahmoud Pashazadeh, The Persian Gulf Nuclear Medicine Research Center, Bushehr University of Medical Sciences, Bushehr, Iran. E-mail: a.pashazadeh@bpums.ac.ir

INTRODUCTION

Today, diagnostic nuclear medicine is playing an important role in diagnostic medicine. This technique is based on detection of gamma photons emitted by radionuclide injected and cumulated in desired organs or tissues. Therefore, nuclear medicine procedures are accompanied with absorption of ionizing radiation which may impose adverse effects on patient's health [1-6]. Although there are number of ways in which health risks of ionizing radiation can be quantified but there is only one way to estimate risks of non uniform exposure. International Commission on Radiation Protection introduced effective dose for this purpose in its radiation safety recommendations in 1977 [7]. Effective dose, expressed in sieverts (Sv) unit, is an indicator of detriment potential of radiation to induce clinically important effects such as cancers [8]. This concept takes into account both severity of the radiation and sensitivity of the exposed tissue. Multiplying the equivalent dose (multiplying absorbed dose by a radiation weighting factor) absorbed in the organ by tissue weighting factor and summing the results over the whole body yields the effective dose [9]. Concept of effective dose was first used for workers dealing with radiation [10, 11]. In the case of medical exposure in which patients undergo diagnostic or therapeutic examinations, concept of effective dose helps physicians to evaluate health risk of radiation on patients. It also gives a simple method to compare risk factor of different procedures and to optimize the procedures utilizing ionizing radiation [7, 9]. Therefore in this study we are going to estimate effective dose per examination and collective effective dose in common nuclear medicine procedures in Golestan province from 2007 to 2010.

METHODS

Our study was comprised of comprehensive data from 10437 nuclear medicine procedures performed by SPECT in nuclear medicine centers of Golestan province during 4 years from 2007 to 2010. This set of data is organized by type and number of procedure, type of radiopharmaceutical and effective dose per exam. All hospitals and private clinics (2 nuclear medicine departments) in Golestan province participated in this study.

Effective dose per examination for various kinds of procedures was estimated using standard patients' dosimetry tables. Collective effective dose (human-Sv) were calculated by multiplying the frequency of the examinations in each year by the corresponding effective dose per examination then summing the results for each year [12].

RESULTS

Details of common nuclear medicine procedures performed during 4 years period in nuclear medicine departments of Golestan province are listed in Table 1.

These informations include type and frequency of procedures, radiopharmaceutical, effective dose and collective effective dose per examinations and also total number of procedures and total collective effective dose per year. According to the data of this table, Tc-99m radiopharmaceutical, in its different forms, was the most common radio isotope (more than 99%) used in these departments leading to highest portion of total collective effective dose (98.3%).

Table 1. Annual number of diagnostic nuclear medicine examination performed in Golestan province and resulted collective effective dose.

Procedure	Radiopharmaceutical	Effective dose per exam(mSv)	Number of procedures				Collective effective dose (Human-mSv)			
			2007	2008	2009	2010	2007	2008	2009	2010
Thyroid	Tc-99m TcO ₄	1.1908	536	432	339	46	638.27	514.43	403.68	54.78
Bone	Tc-99m MDP	3.5796	609	629	661	806	2179.98	2251.57	2366.12	2885.16
Renal	Tc-99m DTPA	1.72627	131	129	81	96	226.14	222.69	139.83	165.72
Renal	Tc-99m DMSA	0.95568	59	93	127	156	56.39	88.88	121.37	149.09
Lung perfusion	Tc-99m MAA	1.5983	64	66	74	131	102.29	105.49	118.27	209.38
Cardiac	Tc-99m MIBI-Rest	5.958	817	673	384	459	4867.69	4009.73	2287.87	2734.72
Cardiac	Tc-99m MIBI-stress	5.2298	777	624	392	463	4063.56	3263.40	2050.08	2421.40
Cardiac	Tl-201 Ion	19.624	27	1	1	6	529.85	19.62	19.62	117.74
Other	Tc-99m TcO ₄	3.848	114	166	123	145	438.67	638.77	473.30	557.96
Total	-	-	3134	2813	2182	2308	13102.82	11114.57	7980.15	9295.94

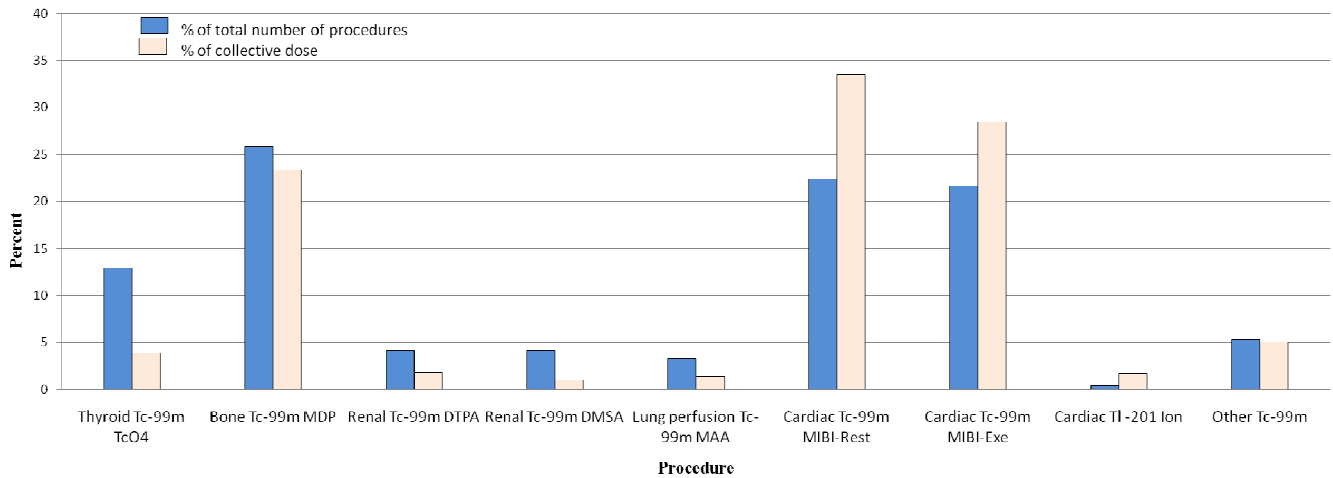


Fig 1. Contribution of each procedure from total number of performed procedures and from total collective dose.

Contribution of each procedure to the total number of procedures and collective effective dose is given in [Figure 1](#). As it is indicated, with respect to the frequency of the examinations, bone scan with Tc-99m MDP (25.9%) was the most performed procedures followed by cardiac scan with Tc-99m MIBI-rest (22.35%) and cardiac scan with Tc-99m MIBI-stress (21.6%). Regarding to collective effective dose, cardiac scan with Tc-99m MIBI-rest (33.5%) had the highest contribution on collective effective dose followed by cardiac scan with Tc-99m MIBI-stress (28.44%) and bone scan with Tc-99m

MDP (23.34%). During 4 years, total number of procedures of 3134, 2813, 2182 and 2308 had lead to total collective effective doses of 13.10, 11.11, 7.98 and 9.29 human-Sv, respectively (mean collective effective dose of 10.37 human-Sv). Percentage of annually performed procedures from total procedures performed during 4 years and corresponding effective doses are given in [Figure 2](#). It is clear the in the first three years number of procedures, collective effective dose and mean effective dose per exam has decreased.

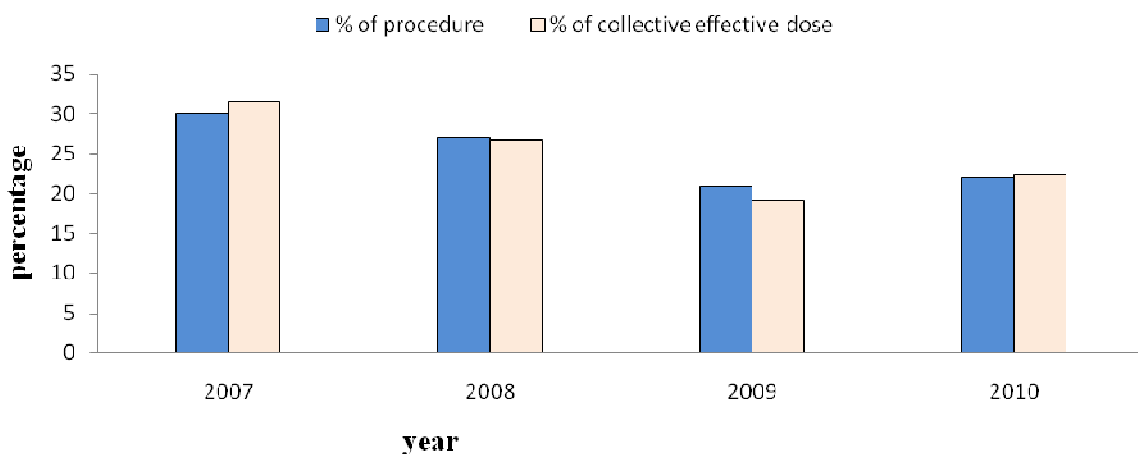


Fig 2. Percentage of procedures and collective effective dose from total number of procedures and total collective effective dose during four years period.

DISCUSSION

Health risk of ionizing radiation is well described by effective dose. This quantity provides an opportunity to compare risks of various radiologic procedures. It can also be useful in modifying corresponding protocols.

Cardiac scan with Tc-99m MIBI-test, cardiac scan with Tc-99m MIBI-rest and bone scan with Tc-99m MDP were the main sources of the collective effective dose among all procedures which resulted in 85.25% of total collective effective dose. While in this study cardiac scan was less frequent than bone scan but because of higher effective dose per scan, cardiac scan had higher contribution to collective effective dose than bone scan. It should be noted that while highest effective dose belongs to cardiac scan with Tl-201, but because of low frequency of this procedure, had not significant contribution on the total collective effective dose in our study.

The highest number of examination was bone scan with Tc-99m MDP. This finding is similar to the report of Shabestani Monfared et al in 2006 [12] in which bone scan had the highest number of examinations among all procedures annually performed in north of Iran. However, in studies performed in other countries the frequency of examinations are not the same indicating that geographical condition is a determining factor on distribution of diseases [12]. High frequency of bone scan in nuclear medicine departments of north of Iran indicates prevalence of bone related disease in this region.

In spite of the findings of Shabestani Monfared et al in which thyroid scan was the second high performed examination (26%), in this study thyroid scan had quite low frequency (13%) and relatively low contribution (3.9%) on total collective effective dose. This comparison indicates that frequency of thyroid scan has significantly decreased from 2006 to 2010. Reduction in the number of thyroid scan is partly due to reduction in the rate of goiter as a result of iodine enriched diets and also as a result of alternative techniques in detection of thyroid related disease.

Findings of present study was also revealed that mean effective dose per nuclear medicine procedures was estimated to be 3.97 mSv. This value is comparable to 3 mSv, reported by Overbeek et al. in 1999 [13]. While this value is higher than effective dose of X-ray based diagnostic procedures but, in general, nuclear medicine procedures lead to lower effective dose per capita of population [14, 15]. This is mainly due to higher number of these procedures in comparison to nuclear medicine.

With respect to the fact that number of nuclear medicine versus radiographic procedures depends on the geographical distribution of the diseases it is recommended to evaluate relative contribution of these two procedures on the effective dose per capita of the population in this province.

CONCLUSION

Beside the cardiac scan which was the most common nuclear medicine procedure and the main contributor of effective dose in patients, due to geographical condition of the northeast of Iran, bone scan was the highest performed nuclear medicine examination in the Golestan province.

REFERENCES

1. National Research Council. Health risks from exposure to low levels of ionizing radiation: BEIR VII Phase 2. The National Academies Press; 2006.
2. Beebe GW. Ionizing Radiation and Health: With the late-appearing effects of exposure to ionizing radiation now well identified, research focuses on the measurement of risk. *Am Sci.* 1982;70(1):35-44.
3. Fazel R, Krumholz HM, Wang Y, Ross JS, Chen J, Ting HH, Shah ND, Nasir K, Einstein AJ, Nallamothu BK. Exposure to low-dose ionizing radiation from medical imaging procedures. *N Engl J Med.* 2009;361(9):849-57.
4. Kohn HI, Fry RJ. Radiation carcinogenesis. *N Engl J Med.* 1984;310(8):504-11.
5. Lewis EB. Leukemia and ionizing radiation. *Science.* 1957 May 17;125(3255):965-72.
6. Wagoner JK, Archer VE, Lundin FE Jr, Holaday DA, Lloyd JW. Radiation as the cause of lung cancer among uranium miners. *N Engl J Med.* 1965 Jul 22;273:181-8.
7. Cember H, Johnson TE. Introduction to health physics. 4th ed. McGraw-Hill; 2009.
8. Danforth RA, Clark DE. Effective dose from radiation absorbed during a panoramic examination with a new generation machine. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2000 Feb;89(2):236-43.
9. Mettler FA Jr, Huda W, Yoshizumi TT, Mahesh M. Effective doses in radiology and diagnostic nuclear medicine: a catalog. *Radiology.* 2008 Jul;248(1):254-63.
10. Gibbs SJ. Effective dose equivalent and effective dose: comparison for common projections in oral and maxillofacial radiology. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2000 Oct;90(4):538-45.
11. Neshandar Asli I, Tabeie F. Pediatric radiation exposure from diagnostic nuclear medicine examinations in Tehran. *Iran J Radiol.* 2005;3(1):35-39.
12. Shabestani Monfared A, Abdi R. The estimation of radiation effective dose from diagnostic medical procedures in general population of northern Iran. *Iran J Radiol.* 2006;3(3):185-8.

13. Overbeek FJ, Pauwels EK, Bloem JL, Camps JA, Geleijns J, Broerse JJ. Somatic effects in nuclear medicine and radiology. *Appl Radiat Isot.* 1999 Jan;50(1):63-72.
14. Regulla D, Griebel J, Nosske D, Bauer B, Brix G. Acquisition and assessment of patient exposure in diagnostic radiology and nuclear medicine. *Z Med Phys.* 2003;13(2):127-35.
15. Schauer DA, Linton OW. NCRP Report No. 160, Ionizing Radiation Exposure of the Population of the United States, medical exposure--are we doing less with more, and is there a role for health physicists? *Health Phys.* 2009 Jul;97(1):1-5.